

ATTENTION IN THE PIGEON: A REEVALUATION¹

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During training sessions, pigeons were successively exposed to compounds consisting of a white triangle on a red background and a white circle on a green background. Key pecking intermittently produced grain reinforcers in the presence of one form-color compound. Once key pecking was confined to the compound associated with reinforcement, the elements—red, green, triangle, and circle—were presented during a test in which no reinforcement was available. Each bird pecked nearly exclusively in the presence of the color previously associated with reinforcement, a result that might be interpreted as indicating that the subjects had attended to color, but not form during training. Pecking was next reinforced when either the triangle or the circle was present. Pecking in the presence of the form previously associated with reinforcement was acquired more rapidly. This result suggests that the birds had learned about the forms during training, and that conclusions about attention based on the lack of differential pecking in the nonreinforcement test may not be appropriate.

Key words: stimulus control, attention, compound stimuli, nonreinforcement test, resistance-to-reinforcement test, key pecking, pigeons

Skinner (1953) defined *attention* behaviorally: an organism attends to a particular aspect of a stimulus if changes in that aspect produce systematic changes in the organism's behavior. Attention is absent if stimulus variation does not produce differential responding. The experiments of Lashley (1938) and Reynolds (1961) are frequently cited as demonstrating attention and inattention, defined in such a fashion.

Reynolds reinforced two pigeons' key pecking with grain when a white triangle on a red background, but not when a white circle on a green background, illuminated the key. This training continued until pecking occurred nearly exclusively in the presence of the triangle and red compound. Next, the color and form aspects of the compound were separately presented during a test in which reinforcement was unavailable. One bird pecked

nearly exclusively in the presence of red; the other pecked nearly exclusively in the presence of the triangle. Reynolds' interpretation was that the first bird had attended to color, but not form, and the second bird to form, but not color, during training.

One potential problem in the behavioral analysis of attention is that the appropriate response or response topography may not be chosen for observation and/or that different test procedures may be differentially sensitive to differences in responding. The consequence of an inappropriate choice, of course, would be to conclude falsely that attention is absent. For example, while Reynolds found that the first pigeon did not differentially key peck in the presence of the forms, there is no certainty that some unrecorded behavior did not differentially occur during these stimuli, or that a different test procedure would not have revealed differential responding.

The present experiment was undertaken to determine if a test procedure other than the nonreinforcement procedure would reveal any evidence of differential responding during the supposedly unattended-to aspect of a stimulus of the type studied by Reynolds. The resistance-to-reinforcement procedure (*cf.* Hearst,

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1972), in which reinforcement for responding was available during each test stimulus, was used.

METHOD

Subjects

Twelve adult White and Silver King pigeons with differing experimental histories were maintained at approximately 85% of free-feeding weights. Two birds are not considered because they failed to respond during the first test session. Water and grit were continuously available in the home cage.

Apparatus

The light-proof, sound-attenuating test chamber contained a ventilation fan, a constantly illuminated houselight, a clear plastic pecking key, an Industrial Electronics Engineers' Model 10-0229 projector, and a grain feeder. The key was mounted behind a circular opening on one wall of the chamber, directly above the feeder. A force of about 0.2 N was required to operate the key microswitch. The projector, mounted directly behind the key, could illuminate the key (except during feeder operations) with red, green, white triangle, or white circle, or combinations of these (BRS/LVE Pattern No. 696). Mixed grain was available for 5 sec during feeder operations. Automatic control of sessions and data recording were arranged by solid-state and electro-mechanical circuits.

Procedure

Birds 1, 2, and 3 had the following training procedures for 29, 21, and 17, 60-min sessions respectively. The key was illuminated by a white triangle on a red background for 80 sec. Key pecks in the presence of this stimulus compound (S+) were reinforced with grain according to a variable-interval (VI) 60-sec schedule. The key was then blank (dark) for 5 sec. The key was next illuminated by a white circle on a green background for 80 sec. Key pecks in the presence of this stimulus compound (S-) and when the key was blank were never followed by grain. The circle and green compound was followed by a 5-sec period during which the key was a blank. After the latter, the sequence was repeated. Birds 4, 5, and 6 received identical training, except for the number of sessions and the fact that the stimuli

that served as S+ and S- were reversed so as to counterbalance the stimuli associated with reinforcement.

The second phase consisted of one session. The procedure arranged during the first 30 min was identical to that described above. During the second 30 min, red, green, and triangle, circle were each presented 10 times for 40 sec. The key was blank for 5 sec before the onset of each stimulus. The order in which the stimuli were presented was randomized, with the restriction that each stimulus occur once in each block of four presentations. No grain was available during the last 30 min.

The third phase also consisted of one session. The procedures arranged during this session were identical to those during the first phase.

The fourth and final phase consisted of 11 to 21 sessions identical to those of the first phase, except that (a) only the triangle and circle alternately appeared on the key, (b) key pecks in the presence of both stimuli were reinforced with grain according to a VI 60-sec schedule, and (c) sessions lasted approximately 30 min.

Birds 7 to 10 were tested to control for the possibility of differential transfer of pecking between different colors and forms. These birds received training identical to that arranged for Birds 1 to 6, except that only the color stimuli appeared on the keys. Training was followed by a single test session identical to that arranged for Birds 1 to 6 during the last phase.

The procedure for all birds is summarized in Table 1.

RESULTS

Training

Table 1 shows the rate of key pecking in the presence of S+ and S- averaged over the last five sessions of training. Key pecking during these sessions was largely confined to the compound of form and color, or color, associated with reinforcement.

Nonreinforcement Test

Figure 1 shows the total number of key pecks made in the presence of red, green, triangle, and circle during the test in which reinforcement was not available. Each bird pecked nearly exclusively in the presence of the color previously associated with reinforcement (red

Table 1

Summary of training procedures and results for all subjects and test results for the control birds.

<i>Experimental Pigeon: 1</i>		<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>	<i>6</i>
<i>Training Sessions</i>						
S+	red + triangle	red + triangle	red + triangle	green+ circle	green+ circle	green+ circle
S−	green+ circle	green+ circle	green+ circle	red + triangle	red + triangle	red + triangle
Number of Sessions	29	21	17	36	37	12
Responses/min during S+	83.2	57.7	66.2	58.6	58.4	51.6
Responses/min during S−	1.1	0.1	0.2	0.2	6.0	0.4
<i>Control Pigeon: 7</i>		<i>8</i>		<i>9</i>		<i>10</i>
<i>Training Sessions</i>						
S+		red	red		green	green
S−		green	green		red	red
Number of Sessions		12	12		12	12
Responses/min during S+		45.7	47.6		64.7	57.0
Responses/min during S−		0.3	0.3		3.8	0.2
<i>Test Session</i>						
Responses/min during triangle		36.6	47.8		52.0	40.0
Responses/min during circle		46.8	47.8		57.4	52.3

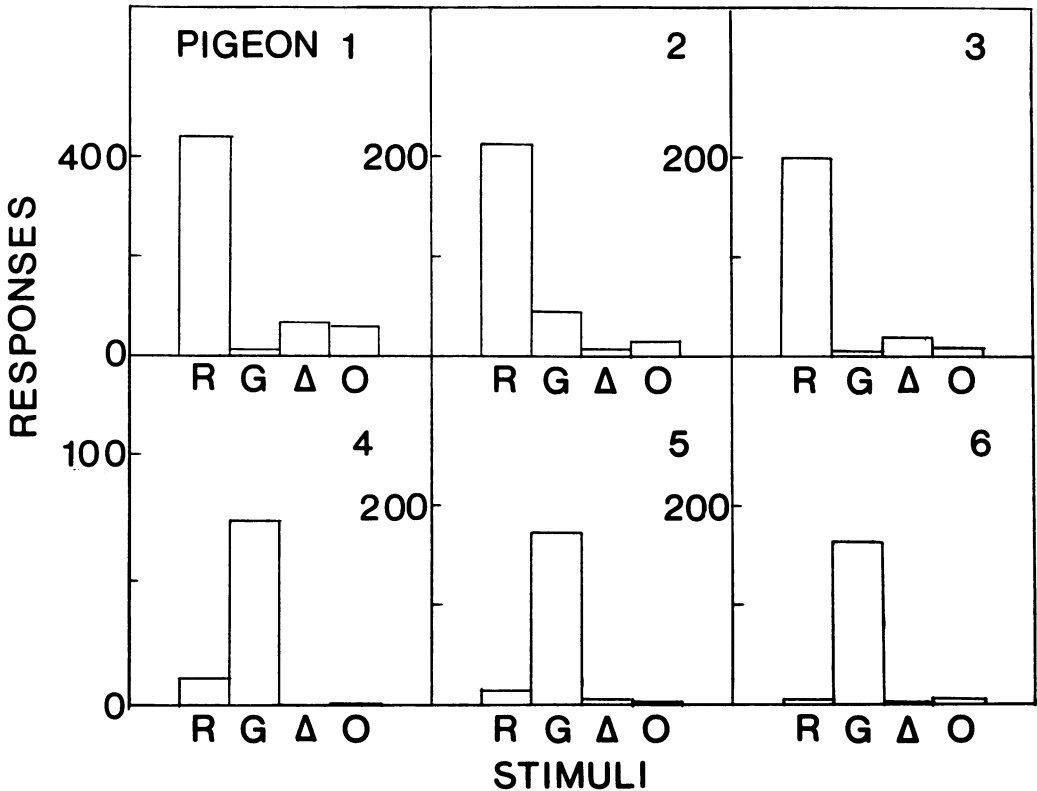


Fig. 1. Total number of key pecks made by Birds 1 to 6 in the presence of red, green, triangle, and circle during a session in which each stimulus was presented 10 times for 40 sec and no reinforcement was available.

for Birds 1 to 3, and green for Birds 4 to 6). Relatively few pecks were made in the presence of the forms and there was no systematic tendency for the birds to peck more often in the presence of the form previously associated with reinforcement.

Resistance-to-Reinforcement Test

Figure 2 shows rate of key pecking by Birds 1 to 6 in the presence of the triangle and circle during the first session in which reinforcement was available during both stimuli. Although each bird received approximately the same number of reinforcers in the presence of the triangle and circle, the rate of key pecking was higher in the presence of the form previously associated with reinforcement (triangle for Birds 1 to 3, circle for Birds 4 to 6). The consistent and immediate differentiation of response rate suggests that the higher pecking rate during the stimulus previously associated with reinforcement was not due to adventitious conditioning (*cf.* Morse and Skinner, 1957). The higher response rate in the presence of the form previously associated with rein-

forcement persisted (Figure 3) in succeeding sessions for all of the subjects except Bird 4. Eventually, responding during the two stimuli converged.

Control Birds

The rate of key pecking by Birds 7 to 10 in the presence of the triangle and circle during the session in which pecking in the presence of both was reinforced is shown in Table 1. Three birds responded more rapidly in the presence of the circle. These results suggest that the response-rate differences in the presence of triangle and circle found for Birds 1 to 6 during the resistance-to-reinforcement test were not due to transfer of pecking from red to triangle and from green to circle.

DISCUSSION

As in Reynolds' (1961) experiment, birds trained to key peck in the presence of one, but not a second, compound of form and color did not peck in the presence of *both* the form and color previously associated with reinforcement

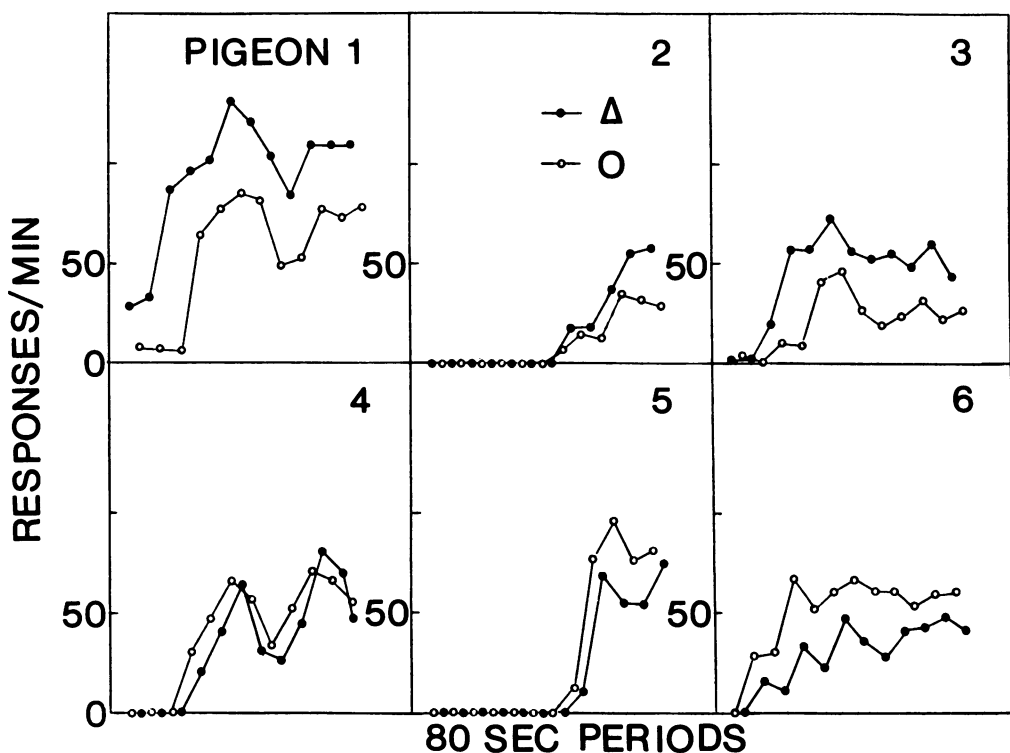


Fig. 2. Rate of key pecking by Birds 1 to 6 in the presence of triangle and circle during successive 80-sec periods of the first session in which pecking in the presence of both stimuli was reinforced.

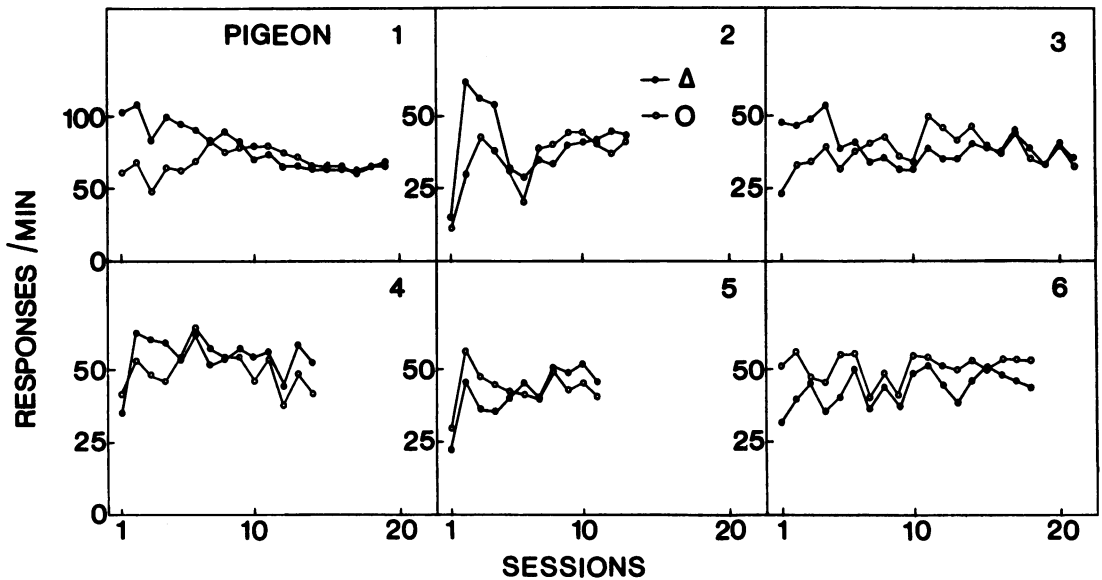


Fig. 3. Rate of key pecking by Birds 1 to 6 in the presence of triangle and circle during each session in which pecking in the presence of both stimuli was reinforced.

during a nonreinforcement test in which the color and form elements were presented. Rather, the birds pecked nearly exclusively in the presence of the color. This result in isolation suggests that the birds had attended to the color but not the form aspect of the compound stimulus during training. The faster acquisition of pecking in the presence of the form previously associated with reinforcement, however, suggests that this interpretation may not be appropriate. Differences in rates of acquisition of pecking during triangle and circle, when pecking in the presence of both was reinforced, imply that the birds had attended to the form aspect of the compound stimulus during training.

The present findings suggest that we should be cautious in making attentional interpretations of other instances of nondifferential responding during an aspect of a redundant compound stimulus. Recent data collected on the blocking effect (Kamin, 1968) by Mackintosh (1975) buttress the need for caution. Kamin (1968), studying conditioned suppression in rats, paired noise and shock before pairing a compound of light and noise with shock. Pretraining with noise blocked differential responding in the presence of light, during a test in which light alone was presented. While this effect is readily described

in terms of failure of attention to light, Mackintosh's (1975) data suggest that blocking is instead due to the fact that attention to light is not *maintained*. Mackintosh found evidence of differential responding in the presence of light after the first, but not additional, compound training trials. Since Mackintosh used only a nonreinforced test for attention it is as yet unclear whether the disappearance of attention to light represents a true cessation of attention, or whether another test procedure would reveal evidence of continued attention. The present results, as well as some recent theoretical analyses by Ray (1969), suggest, however, that the latter might be the case.

The present results also bear on the long-standing continuity-noncontinuity controversy. One of the central issues between Spence (1936) on one hand and Lashley (1942) and Krechevsky (1932) on the other was: when there are redundant aspects of a stimulus differentially associated with reinforcement, does an animal learn only about one or about all aspects? The present evidence that both aspects of a redundant compound stimulus are attended to is congruent with a considerable body of literature (*cf.* Mackintosh, 1974) that in general favors Spence's continuity position.

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